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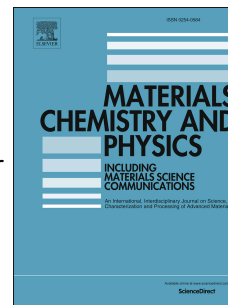
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Design of ceramometal $\text{CuFeAlO}_x/\text{CuFeAl}$ composites and their catalytic potential for water gas shift reaction

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Abstract

Structural, textural-mechanical and catalytic properties of ceramometals synthesized from a powdered alloy with the atomic ratio $\text{Cu}:\text{Fe}:\text{Al} = 45:22:33$ were studied along with the regularities of their synthesis. The alloy was obtained by mechanochemical activation in a high-energy mill for 6-12 min. The resulting powder was subjected to hydrothermal treatment and calcined. The XRD and SEM study revealed that the cermetes have the egg-shell microstructure with the metallic core containing mostly the phases of copper and aluminum intermetallics. The oxide shell contains copper oxide and spinel phases. The catalyst has a considerable (for porous solids) mechanical strength of 14-34 MPa, a developed macropore structure, and a satisfactory specific surface area of 10-23 m^2/g . The specific activity of ceramometals was shown to change with the content of the Al_4Cu_9 intermetallic in the composites are discussed. Interrelation between possible atomic structure of active sites and their catalytic activity is discussed.

Introduction

In industry, the low temperature water gas shift reaction (LT WGS) is one of the most essential ways of hydrogen production. Systems based on Cu, Zn and Al mixed oxides dominate among catalysts for the low-temperature step of this process [1-5]. In some cases, systems based on mixed copper and iron oxides were employed to extend the temperature range and improve stability in the low-temperature water gas shift reaction [6-9]. To enhance the specific activity, it is necessary to increase the specific surface area of metallic copper in the reduced catalyst. Along with this, an important problem is to enhance activity of the unit volume of a reactor, especially for compact fuel cells [1, 4, 10]. This can be reached not only by increasing the activity of the catalyst surface and volume unit, but also by increasing the bulk density of the catalyst bed and decreasing the pore-diffusion resistance owing to the developed macropore structure of the catalyst grains. The latter effect can be obtained with the use of ceramometal catalysts synthesized from alloys with aluminum [11-13]. Thus, the authors of [11, 12] synthesized catalysts for methanol steam reforming from the alloys obtained by self-propagating high temperature synthesis (SHS). The indicated catalysts had a complicated microstructure including the metallic core and the oxide shell, with highly dispersed metallic copper particles formed on its surface. The specific surface area of the catalysts was low due to a high temperature of the synthesis. Also, this method of preparation cannot provide good control of the shape of the catalyst. Ceramometals can be synthesized also by mechanochemical alloying of metals with aluminum followed by hydrothermal treatment of alloys and, finally, by thermal treatment in air [13]. This method prevents SHS, preserves the mesoporous structure of the oxide layer, and makes it possible to synthesize ceramometals of various geometrical shapes. The present work considers the dependence of structural, textural-mechanical and catalytic properties of CuFeAl ceramometals on the time of preliminary mechanochemical alloying of a precursor with the atomic composition $\text{Cu}:\text{Fe}:\text{Al} = 45:22:33$, which was studied earlier [14].

Keywords: CuFeAl ceramometal, texture, water gas shift reaction

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